April 2009
IYA Discovery Guide

This Month's Theme:

Galaxies and the Distant Universe

Featured Activity:

A Universe of Galaxies

Featured Observing Object:

Whirlpool Galaxy

The International Year of Astronomy is a global celebration of astronomy and its contributions to society and culture, highlighted by the 400th anniversary of the first use of an astronomical telescope by Galileo Galilei.
Join us as we look up! http://astronomy2009.us

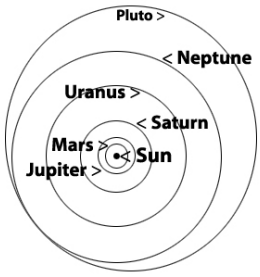
The Astronomical Society of the Pacific increases the understanding and appreciation of astronomy by engaging scientists, educators, enthusiasts and the public to advance science and science literacy.
http://www.astrosociety.org

April's Topic:
Galaxies and the Distant Universe

When Galileo first recorded his telescopic observations of the heavens, he started us on the road to better understanding the structure of the universe. The subsequent discoveries included the sizes and distances of the planets in our Solar System, the stars of our Galaxy, and the rest of the galaxies in our universe.

Many people are still not clear about the difference between our Solar System, our Galaxy, and the Universe. This month's theme and activity will help clarify this. Let's start with some basics.

Our **Solar System** consists of our star, the Sun, and its orbiting planets, along with numerous moons, asteroids, comet material, rocks, and dust.



Our Sun is just one star among the hundreds of billions of stars in our Milky Way Galaxy. If we shrink the Sun down to smaller than a grain of sand, we can imagine our Solar System to be small enough to fit onto the palm of your hand. The diagram at the left is about the right size.

On that scale with our Solar System in your hand, the **Milky Way Galaxy**, with its 200 billion stars, would span North America (see the illustration on the right). Galaxies come in many sizes. The Milky Way is big, but some galaxies are much larger.

The **universe** is all of the galaxies – billions of them! NASA's telescopes allow us to study galaxies beyond our own in exquisite detail, and to explore the most distant reaches of the observable universe. The Hubble Space Telescope and made the deepest image of the universe called the Hubble Ultra Deep Field. Soon the James Webb Space Telescope will also be exploring the most distant edge of the universe, and how galaxies form and evolve.

Learn more about our Universe from NASA.
Find more activities featured during IYA 2009.
See what else is planned for the International Year of Astronomy.
Be sure to take part in the worldwide celebration
100 Hours of Astronomy from April 2-5.

National Aeronautics and Space Administration
Goddard Space Flight Center

The Whirlpool Galaxy (M51) and Companion Galaxy

National Aeronautics and Space Administration
Goddard Space Flight Center

The Whirlpool Galaxy (M51) and Companion Galaxy

Out of This Whirl

The graceful, winding arms of the majestic spiral galaxy M51 appear like a grand spiral staircase sweeping through space. They are actually long lanes of stars and gas laced with dust.

This sharpest-ever image, taken with NASA's Hubble Space Telescope, illustrates a spiral galaxy's grand design, from its curving spiral arms, where young stars reside, to its yellowish central core, a home of older stars. The galaxy is nicknamed the Whirlpool because of its swirling structure.

The Whirlpool's most striking feature is its two curving arms, a hallmark of so-called grand-design spiral galaxies. Many spiral galaxies possess numerous, loosely shaped arms which make their spiral structure less pronounced. These arms serve an important purpose in spiral galaxies. They are star-formation factories, compressing hydrogen gas and creating clusters of new stars. In the Whirlpool, the assembly line begins with the dark clouds of gas on the inner edge, then moves to bright pink star-forming regions, and ends with the brilliant blue star clusters along the outer edge.

Some astronomers believe that the Whirlpool's arms are so prominent because of the effects of a close encounter with NGC 5195, the small, yellowish galaxy at the outermost tip of one of the Whirlpool's arms. At first glance, the compact galaxy appears to be tugging on the arm. Hubble's clear view, however, shows that NGC 5195 is passing behind the Whirlpool. The small galaxy has been gliding past the Whirlpool for hundreds of millions of years.

As NGC 5195 drifts by, its gravitational muscle pumps up waves within the Whirlpool's pancake-shaped disk. The waves are like ripples in a pond generated when a rock is thrown in the water. When the waves pass through orbiting gas clouds within the disk, they squeeze the gaseous material along each arm's inner edge. The dark dusty material looks like gathering storm clouds. These dense clouds collapse, creating a wake of star birth, as seen in the bright pink star-forming regions. The largest stars eventually sweep away the dusty cocoons with a torrent of radiation, hurricane-like stellar winds, and shock waves from supernova blasts. Bright blue star clusters emerge from the mayhem, illuminating the Whirlpool's arms like city streetlights.

The Whirlpool is one of astronomy's galactic darlings. Its beautiful face-on view and closeness to Earth allow astronomers to study a classic spiral galaxy's structure and star-forming processes.

VOCABULARY

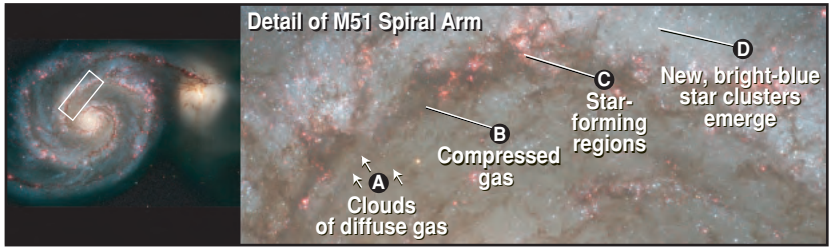
Galaxy: A collection of stars, gas, and dust bound together by gravity.

Stellar wind: Streams of charged particles flowing from the star at millions of kilometers per hour.

FAST FACTS

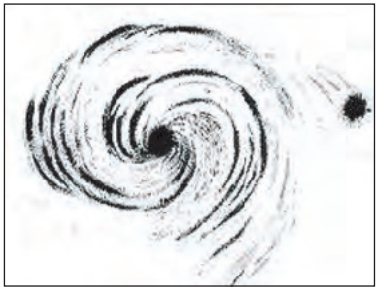
Location: Constellation Canes Venatici (the Hunting Dogs)
Distance from Earth: 31 million light-years
Width (of entire ACS image): 90,000 light-years

Credits: NASA, ESA, S. Beckwith (STScI), and the Hubble Heritage Team (STScI/AURA)



Density-wave theory and spiral galaxies *(above)*. (*A*) Gas in galaxies exists in huge, wispy clouds. (*B*) When these clouds encounter a density wave, they compress into dark, dense gas clouds, called dust lanes. The densest pockets within these dark gas clouds collapse and form stars. (*C*) Thousands of stars are born together in a bright pink star-forming region. (*D*) The largest stars blow away the remaining gas, uncovering bright blue star clusters on the other side of the spiral arm.

Drawing of Messier 51 by William Parsons, the Third Earl of Rosse, compared with Hubble's ACS image (*below, right*). In 1845, Irish astronomer Lord Rosse pointed his 6-foot-wide telescope, the largest of its day, at a mysterious smudge of shimmering light. French astronomer Charles Messier, 72 years earlier, had named the glowing blob M51. But Messier's blob took on a more intricate form with Lord Rosse's powerful telescope. To the Irish astronomer's surprise, the shimmering smudge had a striking pinwheel shape which no one had ever seen before. Lord Rosse called M51 a "spiral nebula," not realizing that the object was a faraway galaxy brimming with stars. His drawing of M51 looks strikingly similar to the image snapped by Hubble's Advanced Camera for Surveys.



You can get images and other information about the Hubble Space Telescope on the World Wide Web. Visit **http://www.stsci.edu/outreach** and follow the links.

The corresponding Classroom Activity for this lithograph can be found at: **http://amazing-space.stsci.edu/** or may be obtained by contacting the Office of Public Outreach at the Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218.

STScI L-05-01 LG-2005-3-089-GSFC

April 2009 Featured Observing Object:

M51: Whirlpool Galaxy

Finder Chart

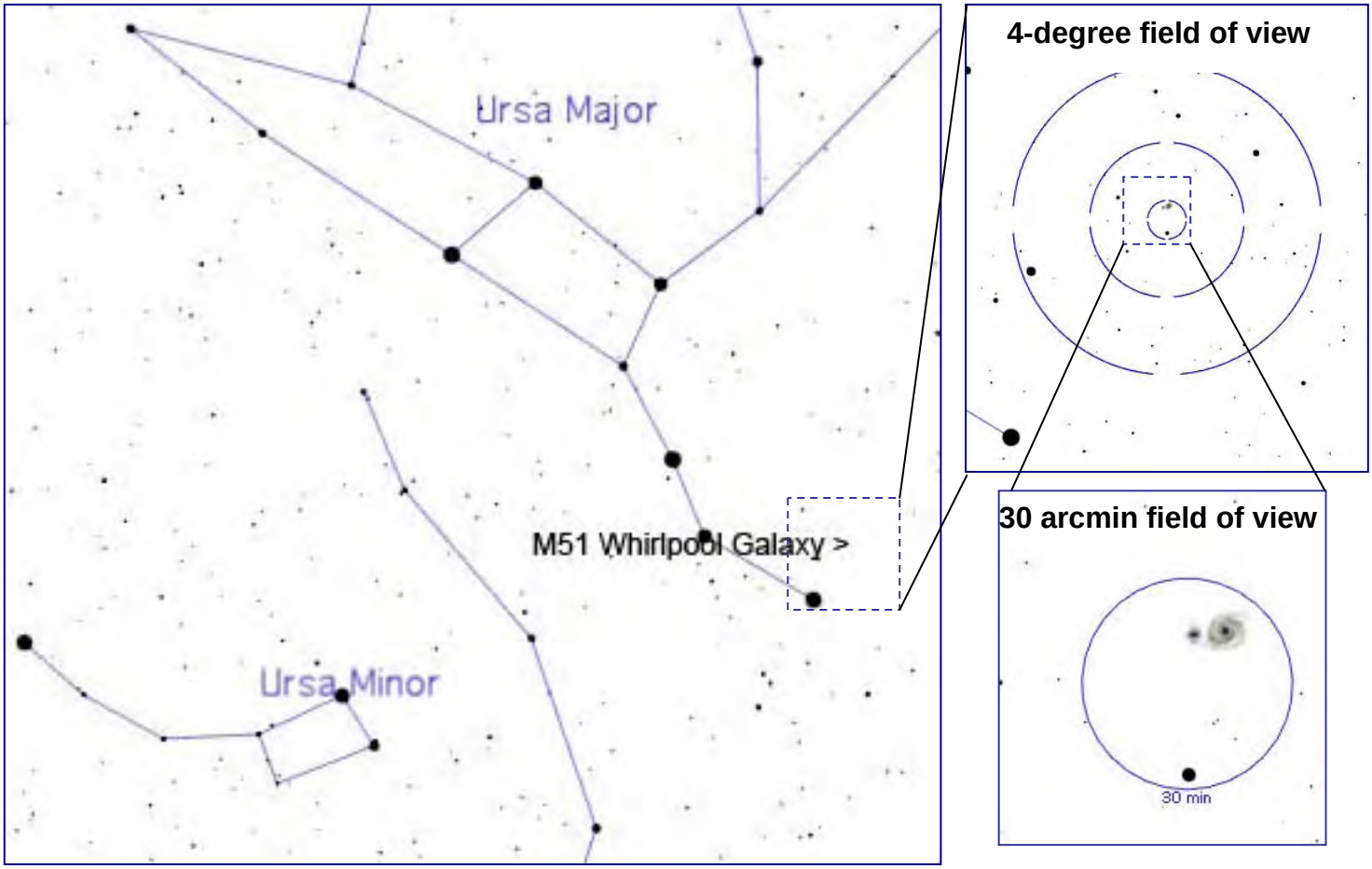
For information about M51: http://seds.org/messier/M/m051.html

R.A. 13h 29.9m
Dec +47:12
Distance: 37 million light years
Visual Magnitude: 8.4
Apparent Dimension: 11x7 arcmins

To View: use a telescope

Image credit: NOAO

Facing north from the Northern Hemisphere, the constellations shown below will be in front of you, above the horizon, in April 2009. (M51 may be difficult to see from the Southern Hemisphere since it will be quite low on the northern horizon.) M51 will be just off the last star in the handle of the Big Dipper (in the constellation of Ursa Major).



Night Sky Network

Astronomy Clubs bringing the wonders of the universe to the public

A Universe of Galaxies

How is the Universe Structured?

About the Activity

Use this model of the Milky Way and other galaxies to indicate relative distances to other galaxies.

Topics Covered

- How far away are the other galaxies?
- How far to the limit of the observable universe?
- Where are we located with respect to other galaxies we see in the telescope?

To Print:

- Visitor Handouts (included below)
- CD label document (below)
  - *(Optional)* The Galaxy CD pages fit Avery 5692 and 8692. These labels simply peel off and attach to the CD.
  - You may want to print more than one of the Milky Way CD Labels for telescope operators to use as a reference.

Participants

This activity can be used with the general public at a star party as well as in a classroom or with youth groups ages 10 and up.

Location and Timing

You will need a large area, e.g. parking lot, playground, or park. The presentation takes about 15 minutes and can be followed up by viewing through the telescope.

Materials Needed

- Telescopes
- 15+ used CDs
- Scissors
- Glue stick
- *(Optional)* Cotton Ball

Included in This Activity

Preparation Instructions
Detailed Activity Description
Helpful Hints
Background Information
Visitor Handouts

Additional astronomy activities can be found here: http://nightsky.jpl.nasa.gov

Preparation Instructions

- Assemble the galaxy CDs. Cut out the CD labels and attach them to the used CDs. Each page contains two sides of the same disk.
- You may want to pull off a small piece of cotton to glue to the center of the Milky Way CD – to represent the central bulge.
- You may want to add club information on the Milky Way Galaxy ("You are here") CD handout sheet.

For a Star Party

- Each participating amateur astronomer may pick any object(s) he or she wishes to show and that his or her telescope is capable of viewing.
- For those amateur astronomers who wish to use the Milky Way CD as a reference, make sure each person has one or the whole set

Detailed Activity Description

At the Telescope:

One of the CDs shows an image of M74, which represents about what our Milky Way Galaxy would look like if we could go far out in space and take a photo of it. The arrow on the CD marks the approximate position of our star, the Sun. The reverse shows the relative distances to other galaxies if our Milky Way was shrunk down to the size of the CD.

You can pull out the Milky Way CD at any time when showing people a variety of objects to give them the sense of distance in relation to our own place in the Galaxy.

For example when pointing out M31, from our position on the Milky Way CD, M31 would be 2.3 meters away. Other galaxies like those listed on the back of the CD are at even greater distances. The limit of the observable universe is out approximately 14 km on this scale.

When showing objects within our Galaxy, you can say that the object is on the CD within a few centimeters of our position (marked by the arrow).

Leader's Role	**Participants' role (expected)**
Introduction: Introduce the activity and explain to the visitors what to expect. You can use the following script, if you wish: *To Say:* What's the difference between the Solar System, the Galaxy, and the universe? (Have a discussion – make sure most people understand the difference – for more details, see the "Our Place in our Galaxy" activity). If we shrink our Galaxy – the Milky Way Galaxy – down to the size of this CD, how far away do you suppose the rest of the galaxies in our universe are? Who wants to be the Milky Way Galaxy? Who wants to be [other] galaxy? *To Do:* Pass out galaxies or have someone pass them out. Don't pass out the Quasar or the Hubble Deep Field. With the Milky Way Galaxy person in the middle, distribute the others around the Milky Way and have them pace off the distance to each of their galaxies.	Discuss ideas. Take galaxies and go out to appropriate distances.

Leader's Role	**Participants' role (expected)**
To Say: Who has a galaxy within 3 meters of the Milky Way? You are in our local group of galaxies – living in the same yard. Who has galaxies within 100 meters? Those are our neighbor galaxies – in the same block. So here are just a few of the billions of galaxies in our universe. These are all fairly close to us. These are galaxies we are able to see in the telescopes you'll be looking through tonight. Now here's one that is over 2 billion light years away [the quasar]. On this scale, it is 2.5 kilometers away. (Hand it to someone) Would you like to take this one to where it belongs? (Hold up the Hubble Deep Field CD) And this is an image of the galaxies in the Hubble Deep Field – some of these galaxies are as far away as our best telescopes can see – over 12 billion light years away! Many of these galaxies are near the limit of the observable universe, which is 13.7 billion light years away. How far away should these galaxies be placed? (Turn over the CD and show the audience the distance on the other side) About 14 kilometers. Who wants to take this one? That would be about as far away as _____ (Pick a city or landmark about 14 km away from your location.) At least 200 billion galaxies are within the observable universe. Imagine CDs distributed all around us – out to 13.7 km away in any direction.	Respond and walk out to correct distance.

Leader's Role	**Participants' role (expected)**
To Say: So, to review: On the scale we've built, how big is our Galaxy, the Milky Way? (Hold up the Milky Way CD) And from how far away can we see light from other galaxies? (Hold up the CD with the Hubble Deep Field on it) NASA sponsors a series of missions to find out more about the very early universe and how galaxies formed within it. So enjoy your evening looking through the telescopes at all the wonderful things within our own Galaxy and looking at some of these galaxies outside of our own!	The size of a CD About 14 kilometers away

Presentation Tips

Shapes of Galaxies:
Of course, not all galaxies are spirals. Some are shaped like giant balls of cotton: ellipticals. Some have irregular shapes – these are appropriately called "irregulars".
Judge if your audience is ready to absorb more information– most need to digest what they have just learned before moving on to more. Each galaxy CD describes the type of galaxy, its approximate shape and size compared to the Milky Way CD.

Our Place in the Universe:
When you say that the observable universe extends 13.7 kilometers in any direction, your audience may have the mistaken impression that we are the center of the universe. One way to answer this is to say:
No matter which of these galaxies you might happen to live in, you would still only be able to see light coming from galaxies no more distant than about 13.7 billion light years – back to just after the Big Bang. Or 13.7 kilometers on this scale. So there is no "center" to the universe. Every galaxy will appear from its own perspective to be at the "center".

Helpful Hints

For online access to the booklet “how big is our universe?” go to:
http://cfa-www.harvard.edu/seuforum/howfar/index.html
After you enter the website, click on “download pdf” or “print-friendly pdf” to download a copy of the booklet.

For a tour of Our Place in Space:
http://cfa-www.harvard.edu/seuforum/opis_tour_earth.htm

Background Information

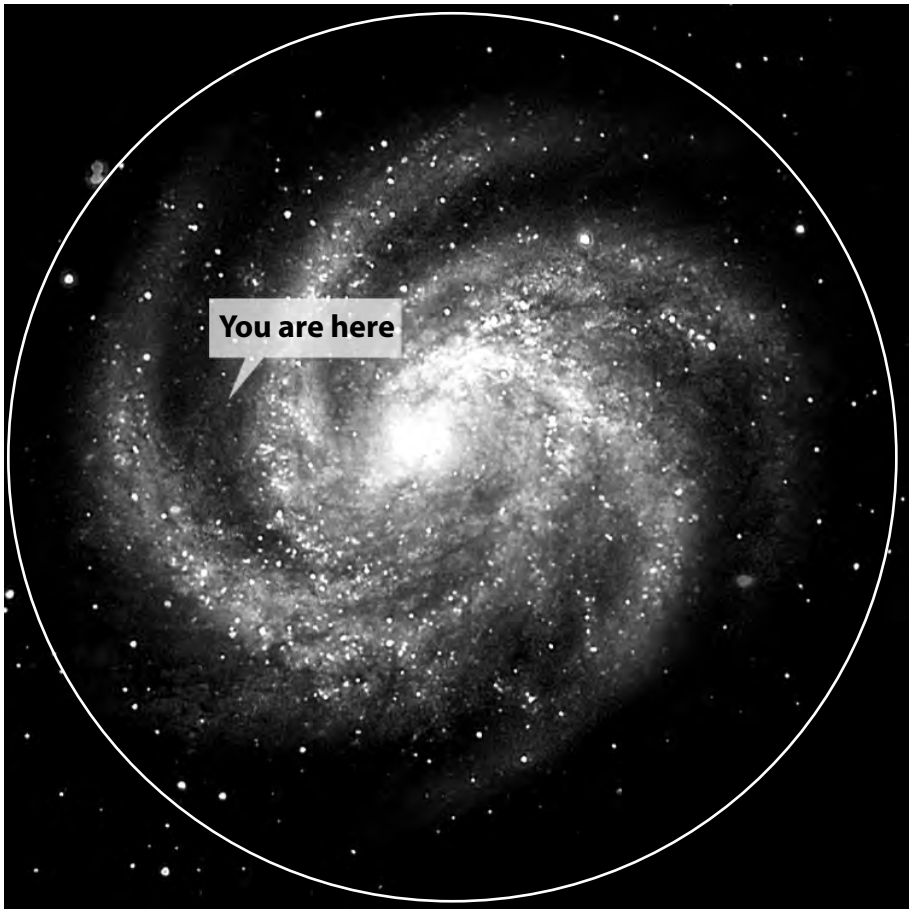
When we show people galaxies through the telescope or describe our own galaxy, it is often difficult for people to get a sense of the distances involved. This activity provides visual props to help to clarify the scale of what you are showing.

The individual stars in each of the photographs of a galaxy can be confusing to some people. Explain that the stars in the photos are here in our own galaxy – we are looking out through the stars in our Galaxy to other galaxies beyond our own – a bit like standing in a swarm of flies and looking out through them to a house several yards away. Or looking out through a dirty, speckled window to the scenery outside.

We cannot see our own star, the Sun, on the Milky Way Galaxy CD. It would be like trying to pick out your porch light on a satellite photo of the USA at night.

Credit: NASA

Make your own!



FRONT

A Universe of Galaxies

The Sun is an average star, located about halfway out from the center of our galaxy.

The Milky Way Galaxy, which is 100,000 light years across, contains about 200 billion other stars.

There are billions of other galaxies in the observable universe, which reaches out 13.7 billion light years.

Using this CD as our Galaxy, the observable universe goes out 13.7 km.

Scale: 1 Million Light Years = 1 meter

BACK

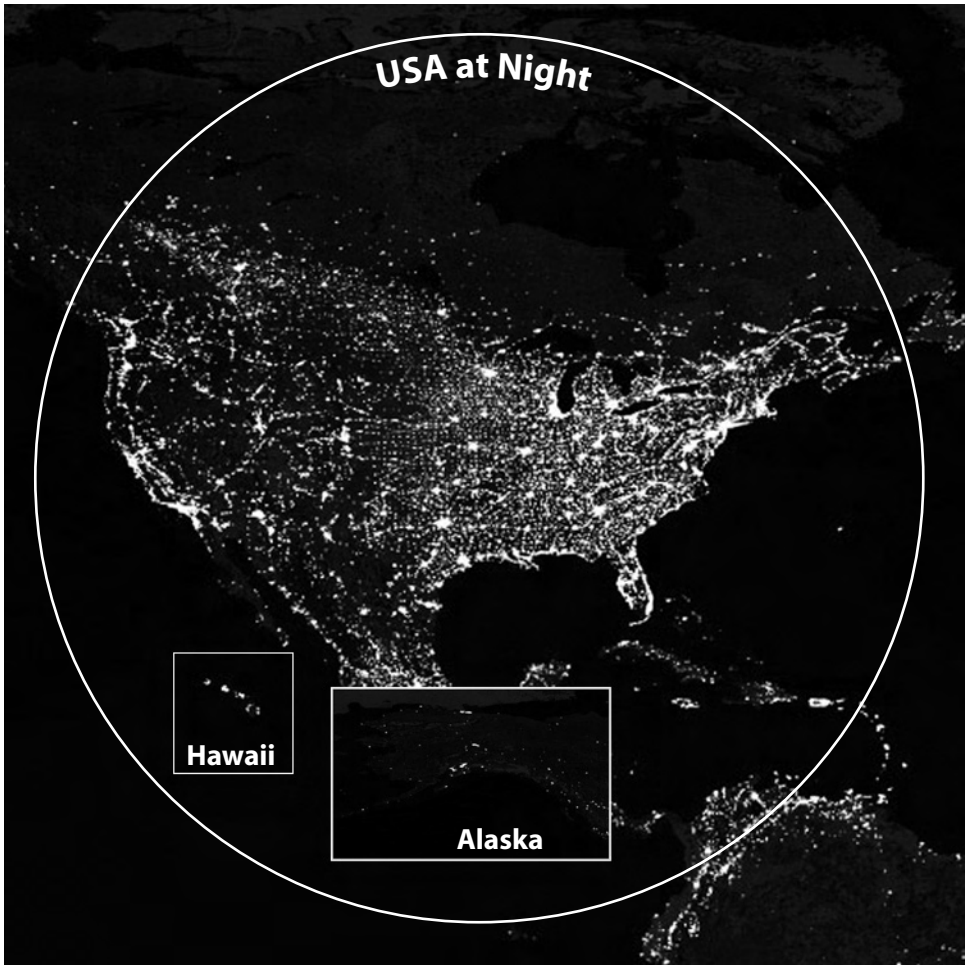
Instructions:
Cut out each circle and glue the "FRONT" to the label side of a used CD. Glue the "BACK" to the other side of the CD.

A Universe of Galaxies

Cut out each circle and glue the "FRONT" to the label side of a used CD.

Glue the "BACK" to the other side of the CD.

FRONT



BACK

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FRONT

A UNIVERSE OF GALAXIES

Milky Way Galaxy

YOU ARE HERE

- We live about halfway out from the center of our galaxy
- The Sun is an average star. The Milky Way Galaxy, which is 100,000 light years across, contains about 200 billion other stars.
- The ratio of our galaxy's width to thickness is almost the same as this CD approximately 100:1

Scale: 1 Million Light Years = 1 meter

Using this CD as our Galaxy, other galaxies would be at the following approximate distances from us:

M31:	2.3 m	**M33:**	2.4 m	**M81:**	12 m
NGC4565:	31 m	**M66:**	35 m	**M51:**	37 m
M104:	50 m	**M87:**	60 m	**3C273:**	2.5 km

Hubble Deep Field

(representing the limit of observable universe)**:** 13.7 km

BACK

Instructions:

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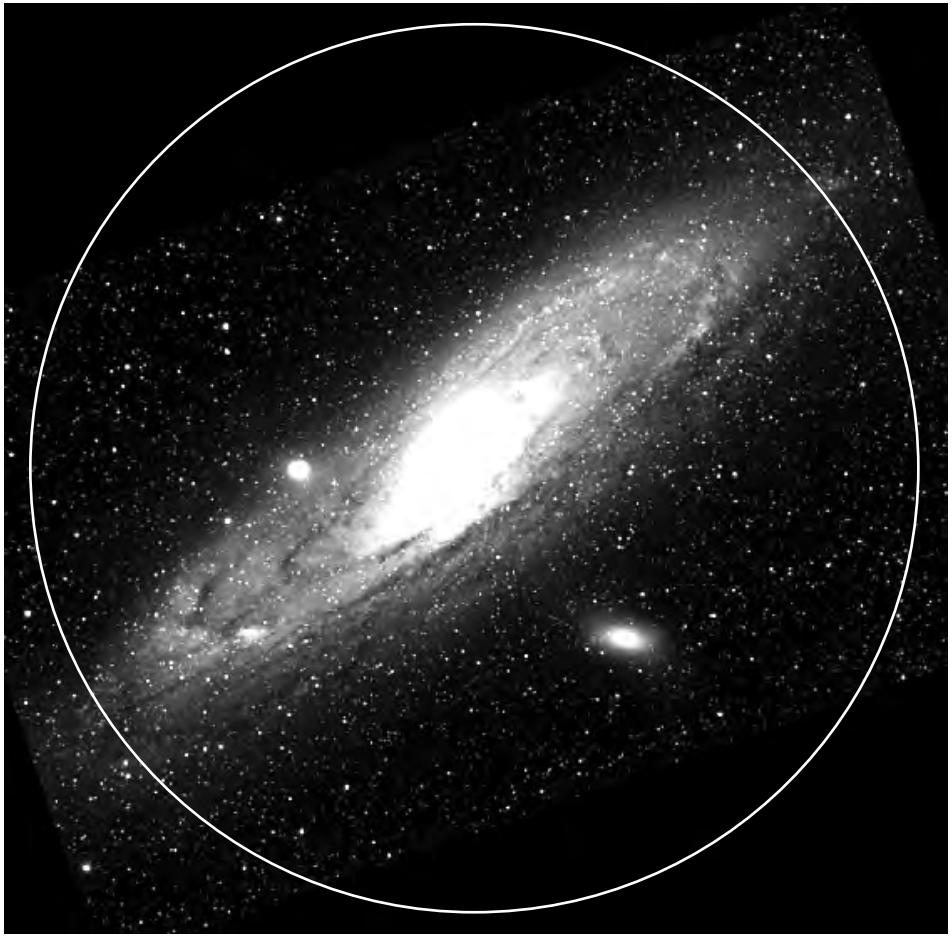


FRONT

M31 – The Andromeda Galaxy

(Oct-Jan)

Spiral Galaxy
Distance: 2.3 million light years
Size: 150,000 light years across

CD Distance Scale:

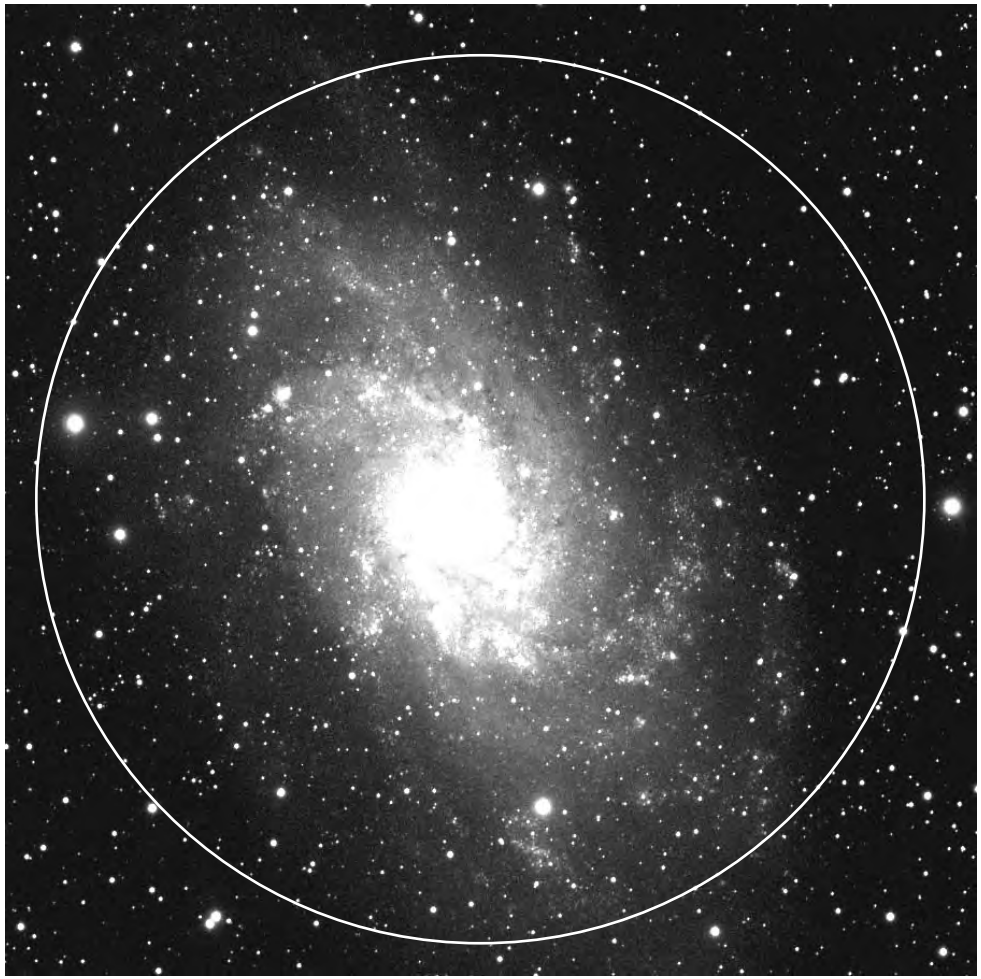
2.3 meters

Size: 15 cm across (salad plate)

A UNIVERSE OF GALAXIES

BACK

Instructions:
Cut out each circle and glue the "FRONT" to the label side of a used CD. Glue the "BACK" to the other side of the CD.



FRONT

M33 – The Pinwheel Galaxy

(Oct-Jan)

Spiral Galaxy
Distance: 2.4 million light years
Size: 60,000 light years across

CD Distance Scale:

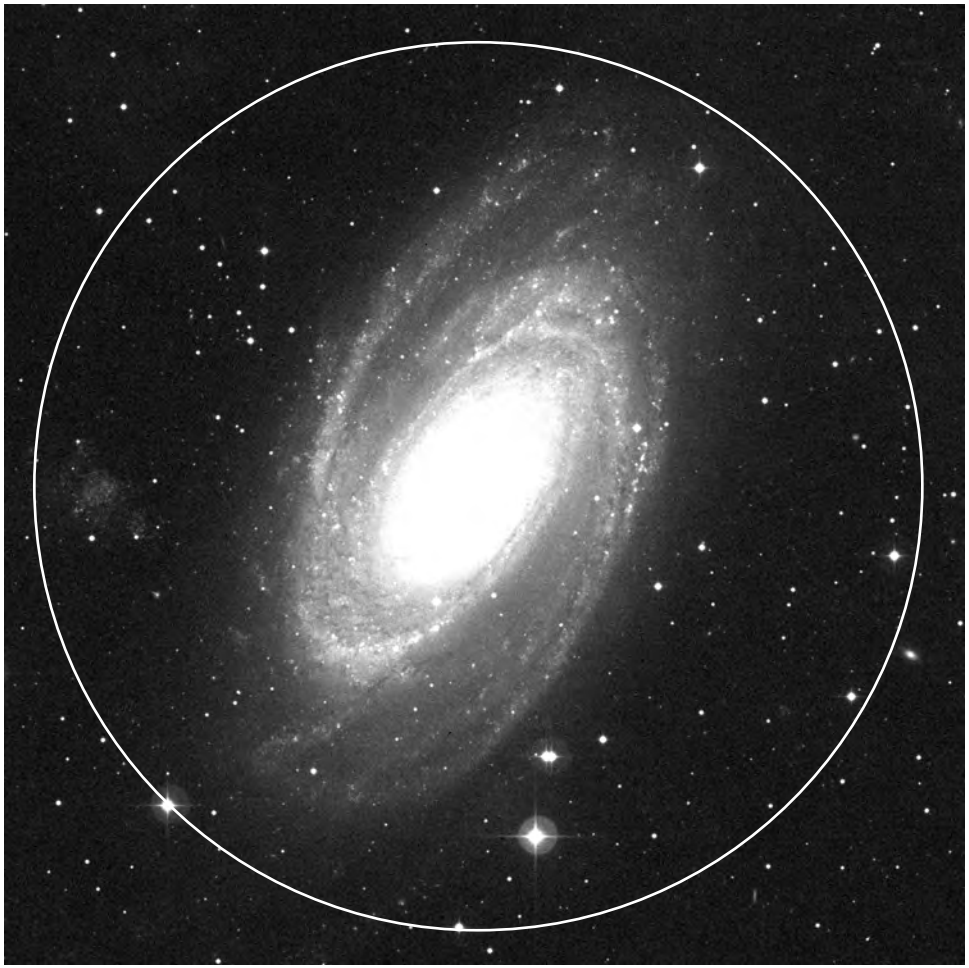
2.4 meters

Size: 6 cm across

A Universe of Galaxies

BACK

Instructions:
Cut out each circle and glue the "FRONT" to the label side of a used CD. Glue the "BACK" to the other side of the CD.



FRONT

M81

(Feb-Jun)

Spiral Galaxy
Distance: 12 million light years
Size: 75,000 light years across

CD Distance Scale:

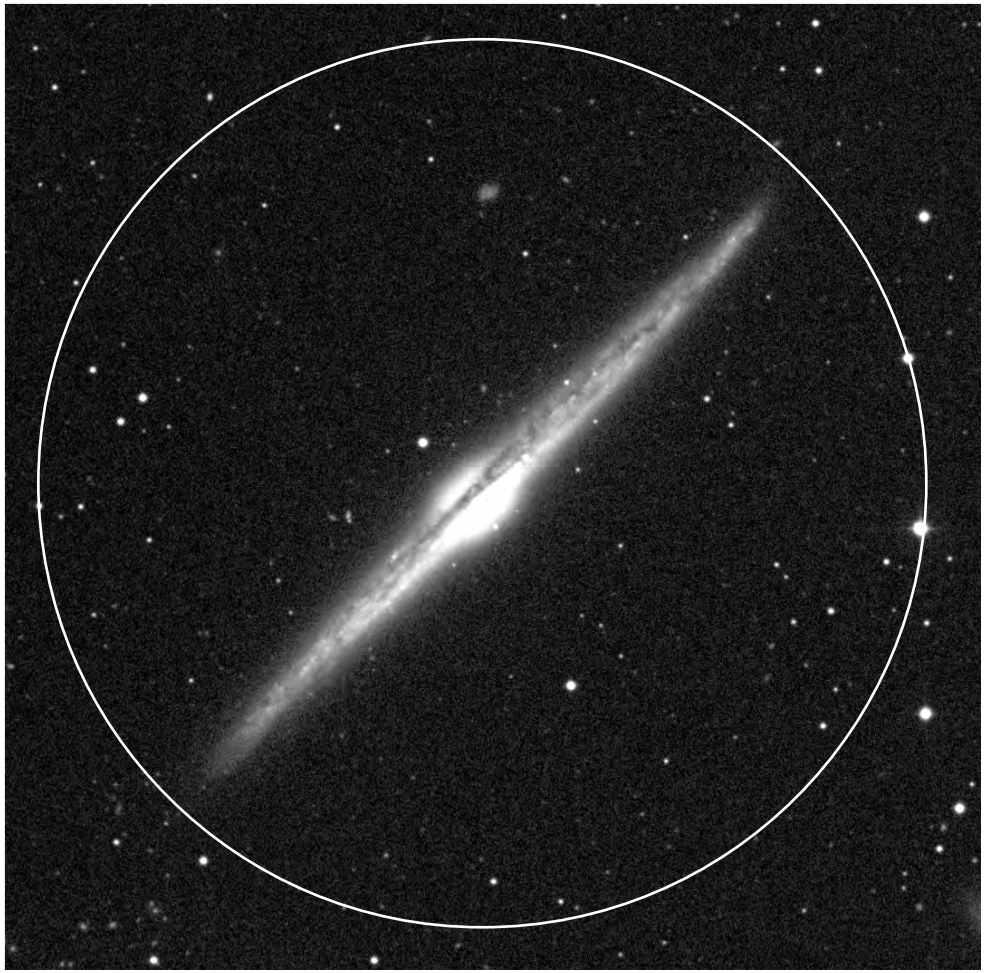
12 meters

Size: 7.5 cm across

A Universe of Galaxies

BACK

Instructions:
Cut out each circle and glue the "FRONT" to the label side of a used CD. Glue the "BACK" to the other side of the CD.



FRONT

NGC4565

(Apr-Jul)

Spiral Galaxy – viewed edge-on
Distance: 31 million light years
Size: 150,000 light years across

CD Distance Scale:

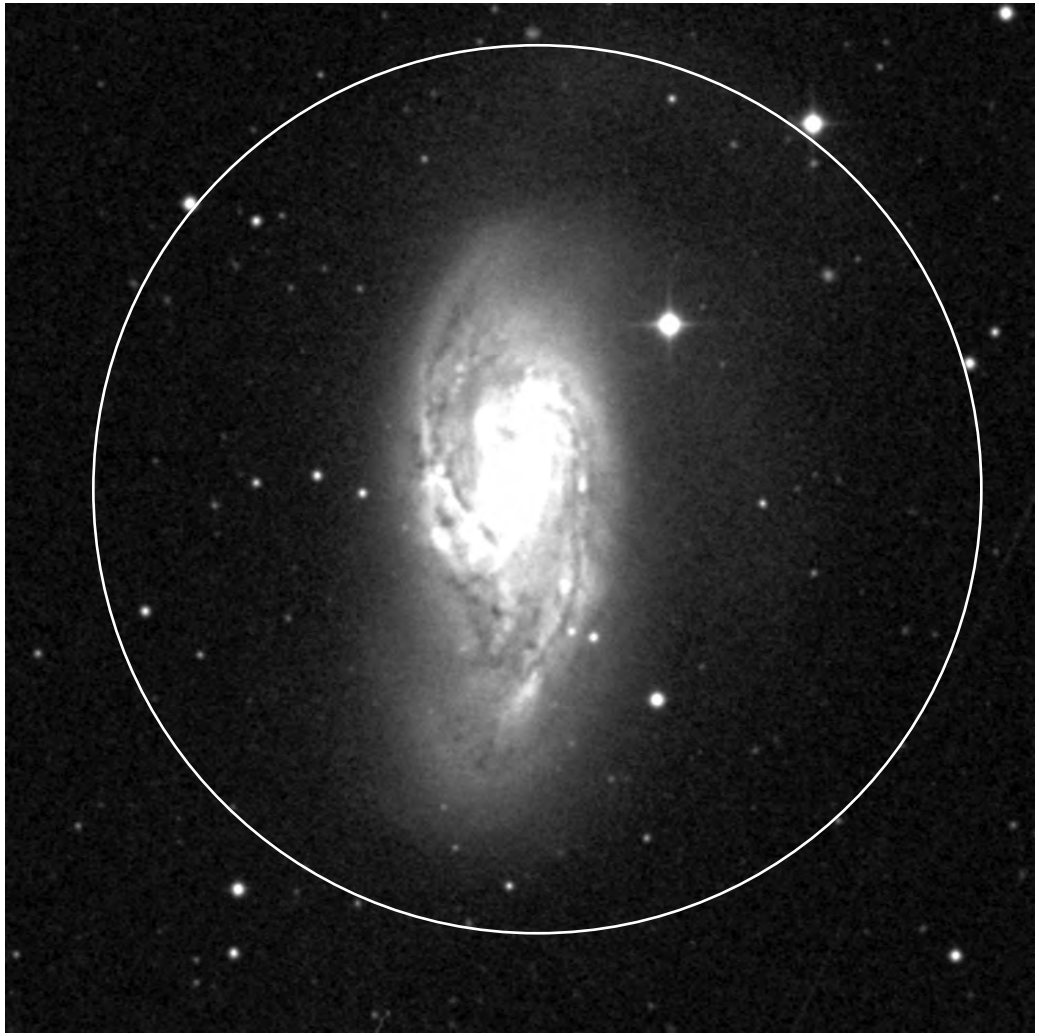
31 meters

Size: 15 cm across (salad plate)

A UNIVERSE OF GALAXIES

BACK

Instructions:
Cut out each circle and glue the "FRONT" to the label side of a used CD. Glue the "BACK" to the other side of the CD.



FRONT

M66

(Apr-Jun)

Spiral Galaxy
Distance: 35 million light years
Size: 80,000 light years across

CD Distance Scale:

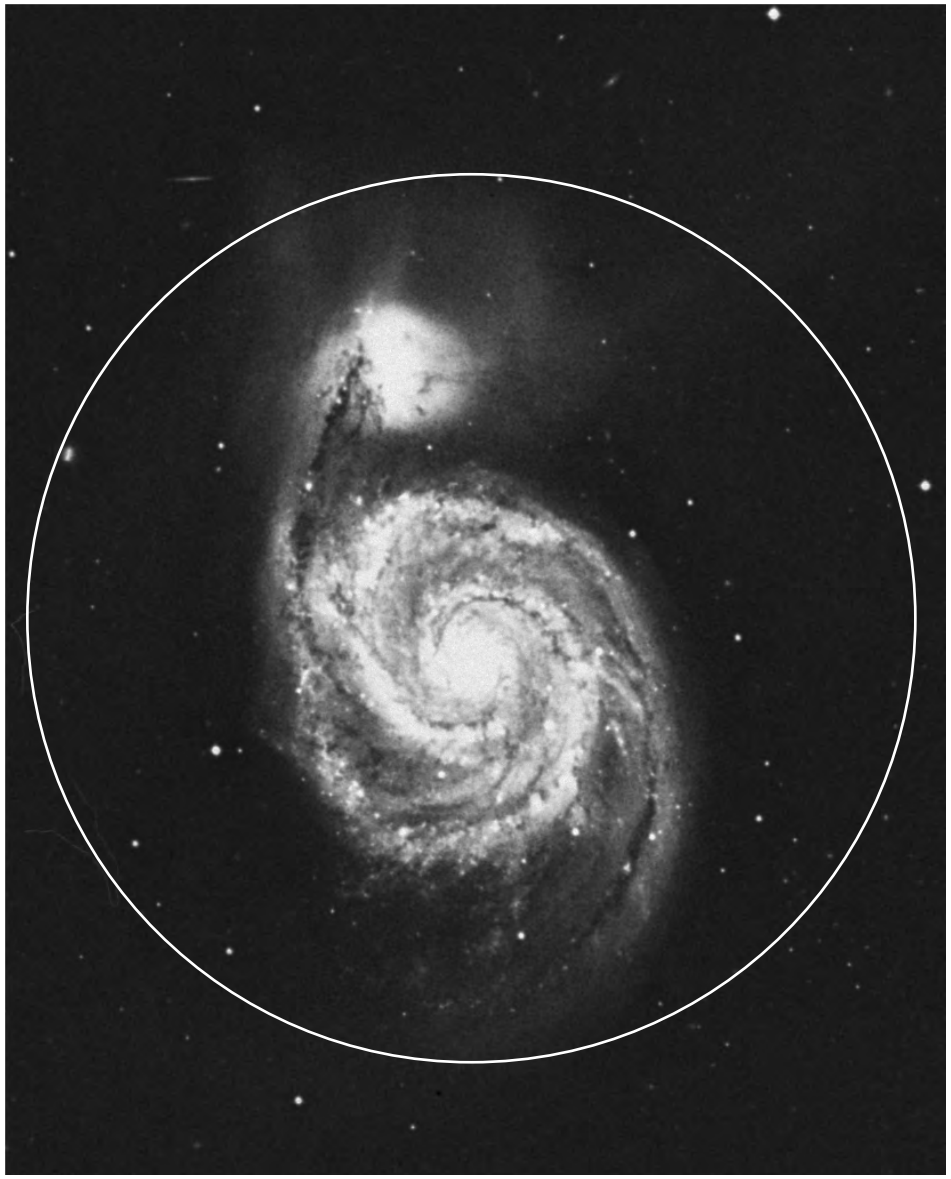
35 meters

Size: 8 cm across

A Universe of Galaxies

BACK

Instructions:
Cut out each circle and glue the "FRONT" to the label side of a used CD. Glue the "BACK" to the other side of the CD.



FRONT

M51 – Whirlpool Galaxy

(Apr-Aug)

Spiral Galaxy with companion galaxy
Distance: 37 million light years
Size: 120,000 light years across

CD Distance Scale:

37 meters

Size: 12 cm across

A Universe of Galaxies

BACK

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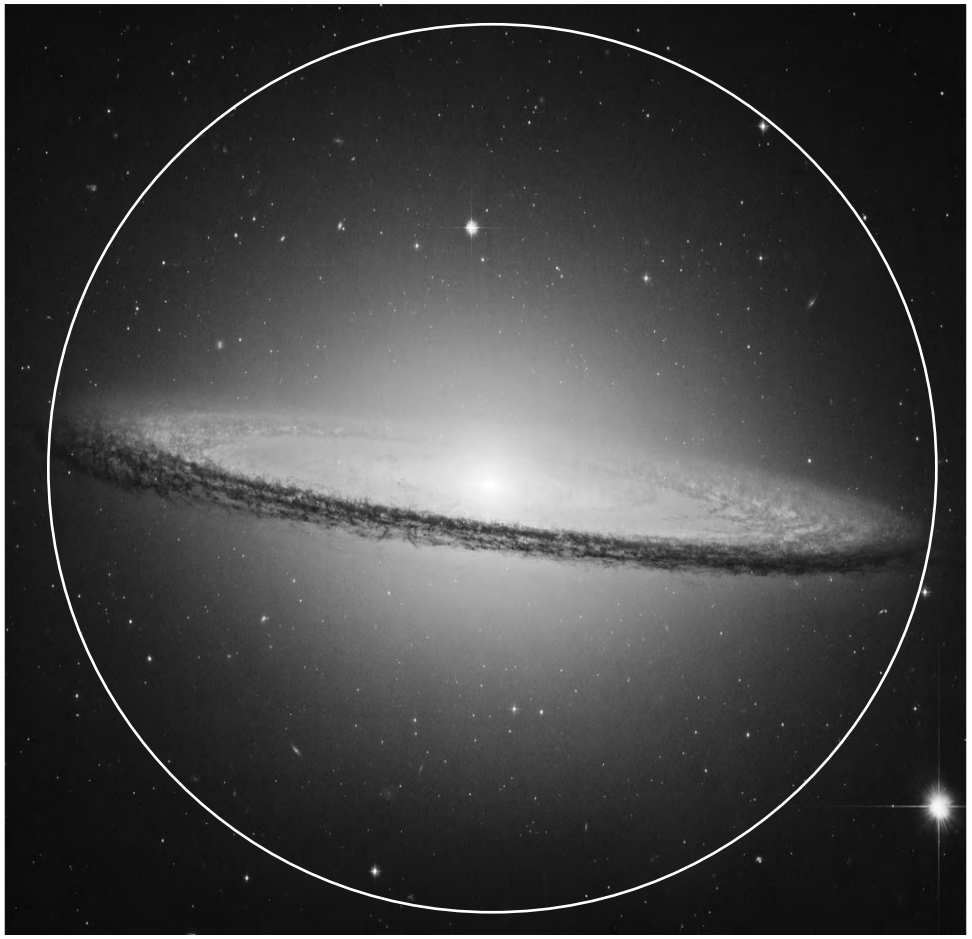

FRONT

M104 – Sombrero Galaxy

(May-Jun)

Spiral Galaxy – viewed edge-on
Distance: 50 million light years
Size: 75,000 light years across

CD Distance Scale:

50 meters

Size: 7.5 cm across

A Universe of Galaxies

BACK

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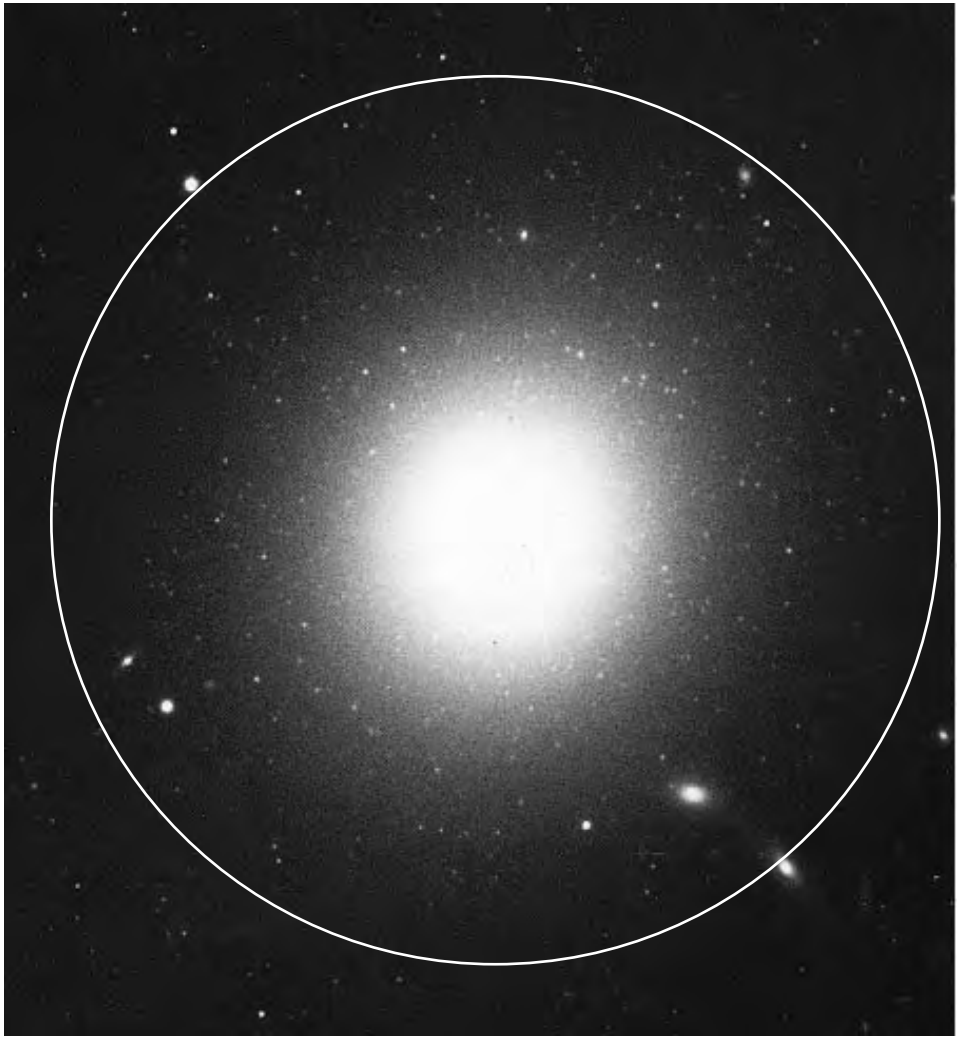

FRONT

M87

(Apr-Jul)

Elliptical Galaxy
Distance: 60 million light years
Size: 120,000 light years across

CD Distance Scale:

60 meters

Size: 12 cm across – like a softball

A Universe of Galaxies

BACK

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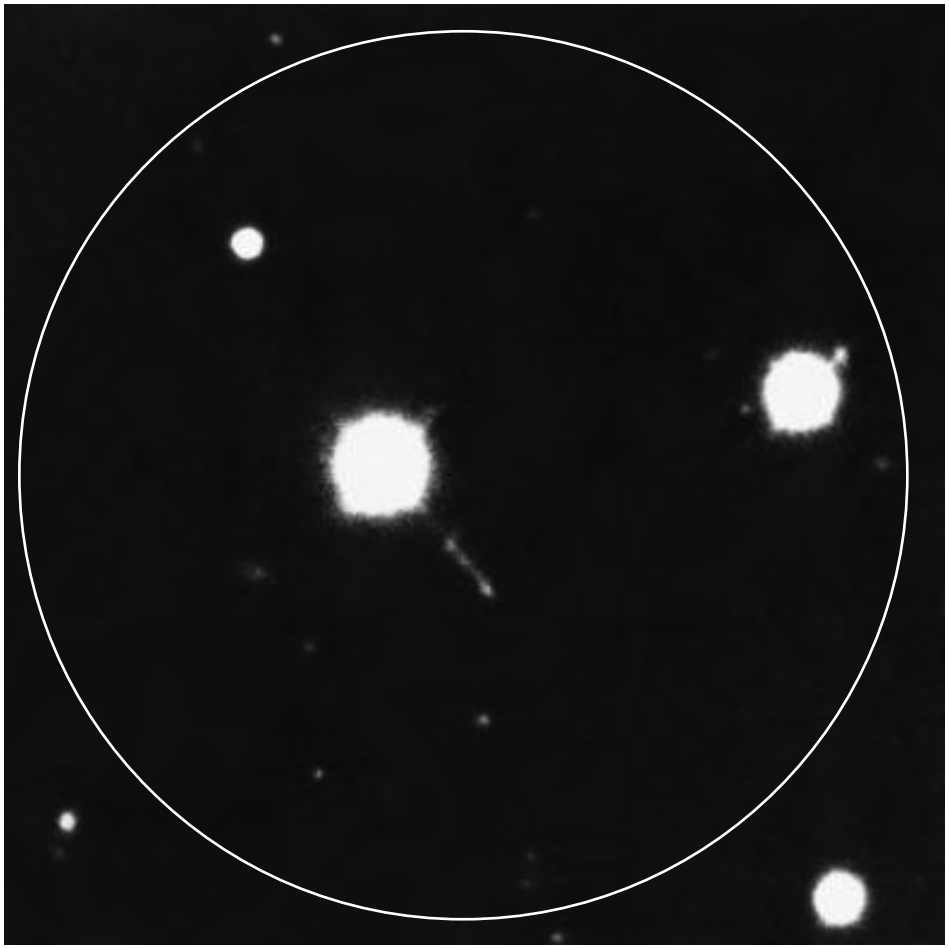

FRONT

Quasar 3C-273

(Apr-Jul)

Elliptical Galaxy
Distance: 2.5 billion light years
Size: 120,000 light years across

CD Distance Scale:

2.5 kilometers

Size: 12 cm across – like a softball

This is the most distant object that can be seen with most backyard telescopes.

A Universe of Galaxies

BACK

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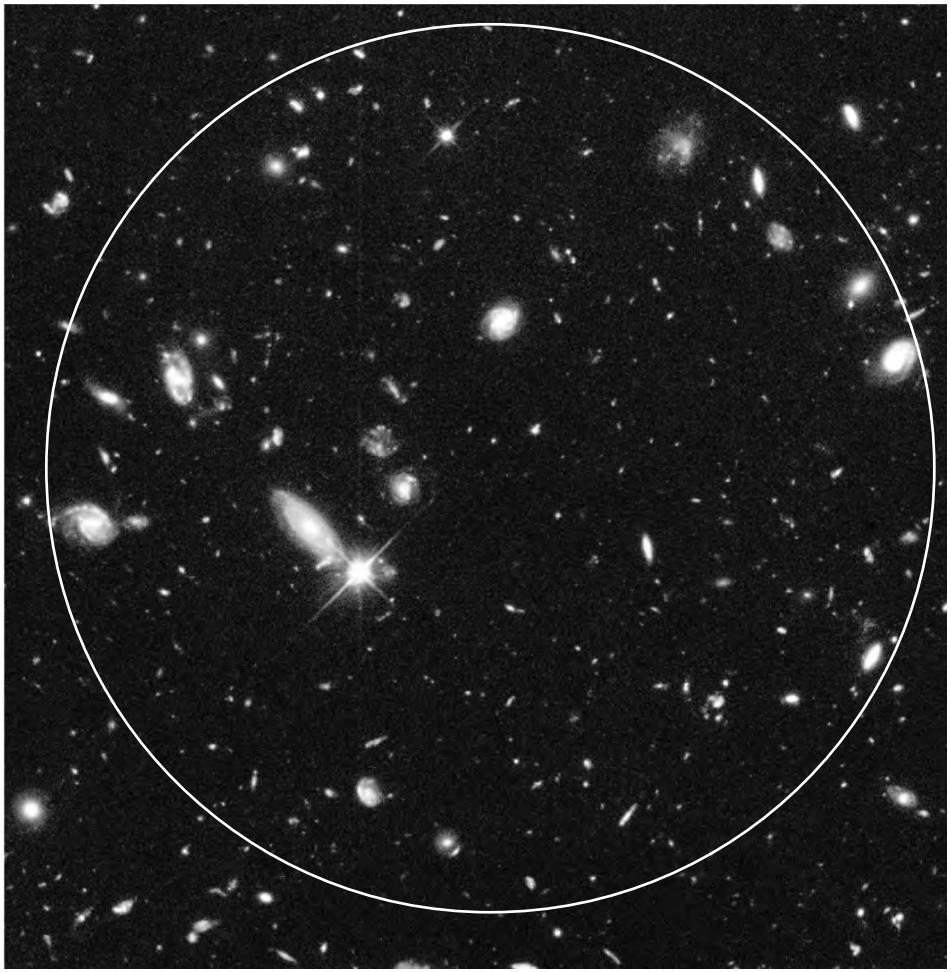


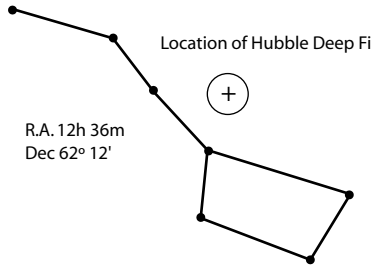
FRONT

Hubble Deep Field

The **Hubble Deep Field** shows some of the most distant galaxies. This image is used to represent the limit of our observable universe: a distance of 13.7 billion light years.

CD Distance Scale:

13.7 kilometers



A Universe of Galaxies

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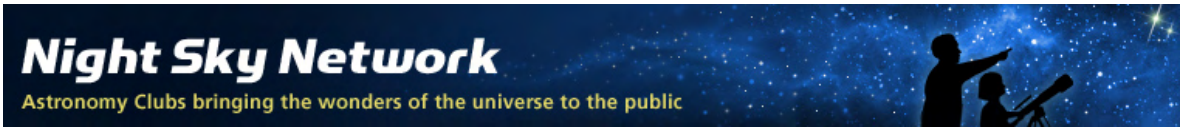
Space Telescope Science Institute's Origins Education Forum
Special Advisor: Denise Smith
NASA JPL's PlanetQuest Exoplanet Exploration Program
Special Advisor: Michael Greene
NASA Lunar CRater Observation and Sensing Satellite (LCROSS)
NASA Education Forum on the Structure and Evolution of the Universe
NASA Education Forum on Solar System Exploration
NASA Education and Public Outreach at Sonoma State University
NASA Goddard Space Flight Center Suzaku Mission E/PO Program
NASA's Kepler Discovery Mission



The Night Sky Network is a nationwide coalition of amateur astronomy clubs bringing the science, technology, and inspiration of NASA's missions to the general public.

We share our time and telescopes to provide you with unique astronomy experiences at science museums, observatories, classrooms, and under the real night sky.
http://nightsky.jpl.nasa.gov

The International Year of Astronomy (http://astronomy2009.us) aims to help citizens of the world rediscover their place in the Universe through the daytime and nighttime sky. Learn more about NASA's contributions to the International Year of Astronomy at http://astronomy2009.nasa.gov